

# VEGETATION DISTRIBUTION AND CHANGE ON OFFSHORE ISLANDS OF THE INVESTIGATOR GROUP AND WHIDBEY ISLES, GREAT AUSTRALIAN BIGHT

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## Summary

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Vegetation on Pearson I., Dorothee I. and Greenly I., South Australia is described and mapped. Limits to potential distribution of woodland, shrubland and heath on the islands appear to be set by physical factors, primarily salt load; but within these limits the distribution at any given time results from successional processes following fire, and dependent on fire intensity and frequency. Multiple successional paths are evident. The wallaby *Macropus eugenii*, introduced to Greenly I., may direct post-fire succession to a grassland endpoint, markedly altering the vegetation relative to that of ungrazed areas. In contrast, transfer of the wallaby *Petrogale lateralis* to previously unoccupied areas does not appear to lead to marked changes in vegetation, although floristic richness is reduced as a consequence. Other vertebrates, particularly seals and sea-birds, have little influence on the vegetation.

Human occupation and land use have been minimal, but have altered vegetation through changed fire regimes and introduction of macropods. Implications for the management of the vegetation are discussed in the light of the observed vegetation change.

## Introduction

Most reports of vegetation of offshore islands in South Australia are of Pearson I., Investigator Group (34°4'S, 134°17'E). The initial observations of Osborn (1923) were supplemented by Specht (1969) and Symon (1971). There is also a number of related reports for this island (Shepherd & Thomas 1971, and other papers in the same volume). There are few published data on vegetation of similar islands in the region, apart from limited floristic records and brief notes for Dorothee I. (34°S, 134°15'E) (Symon 1971) and Greenly I. (34°39'S, 134°45'E) (Finlayson 1948a, 1948b; Mitchell & Behrndt 1949; Cleland 1950).

Since Osborn's visit in 1923, major vegetation changes have been noted on Pearson I. by Specht (1969) and Symon (1971) without consensus of causes. In addition, an expedition in 1960 created a new problem by accidentally releasing Pearson I. Wallabies (*Petrogale lateralis* Gould) and so creating a major colony (Robinson 1980). The impact and potential long-term effect of this introduction have received little attention. There has been no examination of the impact, on Greenly I., of an earlier wallaby introduction; in this case, the Dama Wallaby *Macropus eugenii* (Desmarest) introduced in 1905 (Mitchell & Behrndt 1949).

Other human influences on the islands have been minimal, with little impact from human residence and few recorded plant introductions. The vegetation changes noted despite the apparent lack of human modification may involve processes of consequence to coastal land management elsewhere.

This paper reports the results of quantitatively based, comparative vegetation surveys of Pearson I., Dorothee I. and Greenly I. The work formed part of a comprehensive biological survey undertaken by the South Australian National Parks & Wildlife Service (SANPWS) and the South Australian Museum in November 1976. Information on the vertebrate fauna has been published (Parker & Cox 1978; Robinson 1980).

## Methods

### Plant collections

Comprehensive collecting was attempted on Greenly I., but in view of the extent of earlier collections cited above, effort was directed to seeking species not previously noted on Pearson I. and Dorothee I. All material, mostly vegetative, was deposited in the State Herbarium, Adelaide (AD).

### Vegetation and soils

Base survey data for each island came from 10 m x 1 m quadrats laid singly at intersec-

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tions of an arbitrary, 250 m orthogonal grid (Fig. 1). The sampling established a pool of quantitative information at readily relocatable points for long-term monitoring programmes of the SANPWS. It complemented the formalisation of photopoints used by Osborn (1923), Specht (1969) and Symon (1971).

Each species encountered in quadrats was scored for extent of canopy (the area subtended by the limits of individual canopies), density where appropriate and frequency in ten 1 m<sup>2</sup> cells. Only the first measurement is considered here, being the parameter most readily compared between unrelated species. The raw data are on file at SANPWS offices, Adelaide.

Quadrat data and subjective observation of community structure were both used to define vegetation mapping units. Recent aerial photographs were then interpreted for mapping purposes. The photographs predated fires on Pearson I. in April 1975 and Greenly I. in February 1974, and the maps display the prefire vegetation.

Quadrat sampling was necessarily limited by time. While the data did indicate major site and vegetation interactions, laid quadrats alone were not sufficiently numerous to place these interactions in sharp focus. Clarification was attempted by an artificial augmentation of sample size. A supplementary grid of 125 m interval was superimposed on the 250 m base grid and the vegetation unit at each point read from the compiled vegetation maps. This information was later used in correlating vegetation type (mapping unit) with sampling site topography and location. The validity of this approach is argued on two grounds: one quarter of all such points did in fact have a quadrat laid at them; and most of each island was traversed by observers during survey. Interpolation was realistic in these circumstances. The approach has the disadvantage that discussion of relationships must necessarily concern mapping units rather than individual species.

Generalised soil types (*sensu* Osborn 1923 and Specht 1969) were noted at each quadrat and on general reconnaissance, but few cores were taken in view of the information already available and the simplicity of the soils (see Twidale 1971).

#### Vertebrates

Most observations of vertebrates come from Parker & Cox (1978) and Robinson (1980),

but some were made during the vegetation survey. Densities of wallaby pellets were counted in quadrats on Pearson I. and Greenly I. The distribution and density of seal dung was noted, and the movements of seals observed on all islands. Of the two species present, the Australian Sea Lion *Neophoca cinerea* (Peron & Lesueur) was observed frequently in vegetated areas. The New Zealand Fur Seal *Arctocephalus forsteri* (Lesson) did not appear to move inland beyond bare rock near high water mark.

#### Human influences on the islands

The three islands are uninhabited. They have never been subject to domestic grazing or cropping because of their topography and relative isolation. Some sealing took place in the 19th and early 20th century: Mitchell & Behrndt (1949) mention a sealer who "spent many months" on Greenly I. at the turn of the century. Earlier sealing may have been as intensive on Kangaroo I. and the Bass Strait islands (Wood Jones 1923-25; p.373 *et seq.*). Sealers were visiting the Nuyts Archipelago to the west by the 1830's (N. Waac, pers. comm.). No evidence remains of sealing activity.

Pearson I. has a small, automatic navigational light which is serviced by helicopter. Associated impacts are limited to a cleared helipad and used battery dumps. The extensive changes often associated with manned light stations have been avoided (see Hope & Thompson 1971).

The major human impacts are caused by casual visitors. Wallaby introductions are noted above. Fires in 1974 on Greenly I. were lit by tuna fishermen (Robinson 1980), and Osborn (1923) reported that fires preceding his visit to Pearson I. also had been deliberately lit. The 1975 fires on Pearson I., however, resulted from lightning strikes (Robinson 1980). The introduction of the few alien plant species to the islands are also a likely result of visits. Such influences are slight by comparison with those documented elsewhere (Norman 1967, 1971; Hope & Thompson 1971). They may nevertheless have affected the structure and composition of the present vegetation more than is apparent.

#### Climate

The meteorological stations nearest to the islands are on the west coast of Eyre Peninsula. The following, based on these records (Anon.

1961), represents only a general indication of the island climates.

The climate is semi-arid: mean annual rainfalls at Streaky Bay and Elliston are 380 mm and 430 mm respectively. Mean annual temperature at Streaky Bay is 17° C, with mean maximum 23° C and mean minimum 12° C. Rainfall seasonality is pronounced, with most rain in autumn-winter. The wind-field in summer is dominated by southwesterly sea breezes, but winter winds alternate between northerly and southwesterly; the latter associated with eastward-moving low pressure systems and cold fronts.

Prevailing ocean swells are from the southwest with an approximate height range of 1-4 m, consequently the western faces of the islands have higher energy coasts than other aspects (Shepherd & Womersley 1971; Twidale 1971).

#### Physical features

Dorothee I. is a single land mass, but Pearson I. and Greenly I. are subdivided respec-

tively by a floodway and a narrow chasm (Fig. 1). The dividing seaways are dispersal barriers to terrestrial mammals (Mitchell & Behrndt 1949; Thomas & Delroy 1971; Schmitt 1975, 1978). The sections are here considered as individual islands for convenience in later discussion: North and South Greenly I., and North and South Pearson I., where the last comprises the connected 'Middle' and 'South Sections' of Osborn (1923).

The islands are all inselbergs of Gawler Block granites (Webb & Thomson 1977), and the geomorphological discussion of Twidale (1971) is relevant to all. Hence only those physical characteristics most likely to be reflected in the vegetation are discussed here: variation in the degree of protection from sea-spray and cyclic salt, and variation in soil type.

The salt load is likely to be the initial determinant of plant distributions on small islands (Parsons & Gill 1968; Specht 1972;

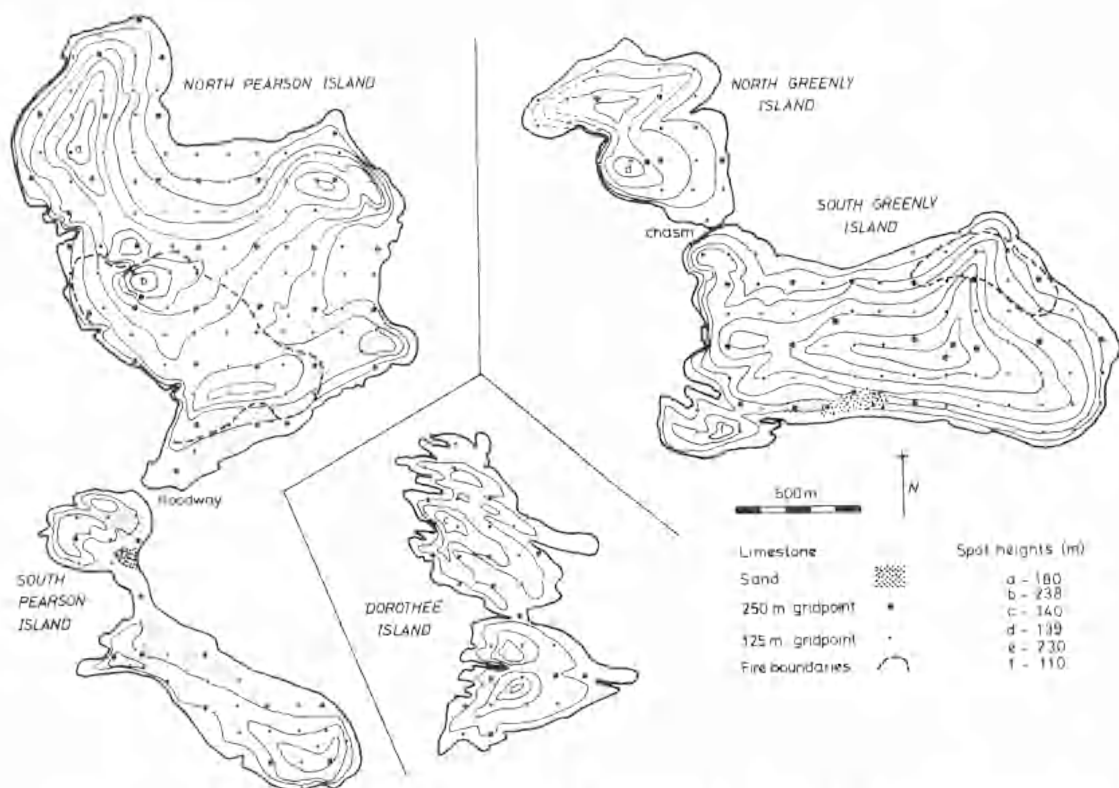


Fig. 1. Pearson, Greenly and Dorothee Is, showing topography, extent of limestone terraces, and sampling grids. Burnt areas discussed in text are indicated. Maps compiled from uncontrolled aerial photographs: form lines approximate 30 m contours.

TABLE 1. *Geographic data.*

Island	Planimetric area (ha)	Mapped shoreline (km)	Area: shoreline ratio (ha:100 m)	Maximum altitude (m)
N. Pearson	170	6.4	2.7	238
S. Greenly	125	6.3	2.0	230
Dorothee	57	5.2	1.1	140
S. Pearson	50	4.6	1.1	116
N. Greenly	37	3.0	1.2	140

TABLE 2. *Floristic summaries.*

(a) <i>Number of plant species in common (data from all records)</i>					
Pearson I.		Dorothee I.		Greenly I.	
80		38		30	
		40		21	
				37	
				Pearson I.	
				Dorothee I.	
				Greenly I.	
(b) <i>Number of species in common (data from 1976 survey)</i>					
N. Pearson I.	S. Pearson I.	Dorothee I.	N. Greenly I.	S. Greenly I.	
53	22	28	28	24	N. Pearson I.
	22	18	17	14	S. Pearson I.
		31	19	16	Dorothee I.
			37	29	N. Greenly I.
				29	S. Greenly I.

Randall 1970a). Even on the smallest of the islands examined, significant variation in salt load can be expected because of the very rapid reduction in the amount of air-borne salt with increasing altitude and distance from the sea (Yaalon & Lomas 1970; Waisel 1972) and the variation of the initial salt input in relation to aspect, wave action and prevailing winds (Randall 1970b). In these terms N. Pearson I., S. Greenly I., N. Greenly I. and Dorothee I. form a graded series, with the first (the highest, most compact and topographically most varied; Table 1, Fig. 1) providing the greatest range of protected sites. The series is also almost one of size. The diminutive N. Greenly I. precedes the larger Dorothee I. primarily because of the protection offered by its precipitous western cliffs and the shelter of its immediate neighbour.

S. Pearson I. does not readily fit the series because of its soils. On all the other islands, the predominant soil is a uniform granitic fine gravel or coarse sand on a basement of granite, but on S. Pearson I. limestone is equally important as a basement, with superficial soils ranging from loam to coarse granitic sand. Limestone terraces are found on N. Pearson I. but account for a much lower proportion of the total land area than on S. Pearson I. (Fig. 1). There is no limestone on Dorothee I. or N. Greenly I., but remnants

were observed on S. Greenly I. at approximately the same level as the Pearson I. terraces. Two additional, minor soil types exist. Blown sand is found on S. Pearson I. and S. Greenly I., the latter containing a sea-bird colony. A calcareous sandy loam of high organic content occurs over less than 1 ha on Dorothee I.

## Flora

### *Records and additions*

Floristic records are presented in Appendix 1 and summarised in Table 2. New additions to the known floras are (a) Pearson I.: *Monotoca scoparia* (Sm.) R. Br. on East and North Hills; (b) Dorothee I.: *Brachyscome iberidifolia* Benth. in the southern part, *Cotula vulgaris* Leutn. over most of the island, and *Olearia ramulosa* (Labill.) Benth.; (c) Greenly I.: *Notodanthonia racemosa* (R. Br.) Zotov., *Arthrocnemum halochnemoides* Nees, *Enchylaena tomentosa* R. Br., *Maireana oppositifolia* (F. Muell.) P. G. Wilson, *Rhagodia baccata* (Labill.) Moq., *Carpobrotus rossii* (Haw.) Schwantes, *Disphyma australe* (Ait.) N. E. Brown, *Scleranthus pungens* R. Br.

The identity of *Olearia* bushes is uncertain: a result partly of the lack of flowering material in collections and partly of the marked phenotypic plasticity of species. *O. ramulosa* only has been reported from Pearson I. (Osborn

1923; Specht 1969) and *O. axillaris* only from Dorothee I. and Greenly I. (Symon 1971; Cleland 1950). Field recording followed the reported nomenclature. A recheck of AD specimens brought to light a vegetative voucher from Dorothee I., collected by Symon and placed in *O. axillaris*, which appears to be *O. ramulosa*. Unfortunately, the wide individual variation of specimens in the field prevented detection of this at the time of survey. Hence the two species are treated as one taxon, *Olearia*, in subsequent discussion.

#### Comparison of island floras

Only species recorded during field survey should be considered for comparative purposes, on grounds of equivalent observational effort between islands. N. Pearson I. had the most varied flora. All species on S. Pearson I., almost all species on Dorothee I. and S. Greenly I., and three quarters of species on N. Greenly I. were in common with the N. Pearson I. flora (Table 2). Fourteen species were found only on N. Pearson I. (Table 3): on the mainland the majority comprises heath or understorey plants which are uncommon on the immediate coast (Specht 1972). N. Pearson I.'s extensive limestone areas did not appear to influence species richness, as no species restricted to such areas were found.

Thirty-seven species were found on Greenly I. All were present on the northern section, but a number were missing from S. Greenly I. Six species were found only on Greenly I.: *Stipa elegantissima*, *Scirpus nodosus*, *Maireana oppositifolia*, *Helichrysum bracteatum*, *Mueh-*

*lenbeckia adpressa* and *Euphrasia collina* var *tetragona*. All are common in immediately coastal habitats on Eyre Peninsula (Specht 1972). *Atriplex cinerea* was not found at all on the island, despite its abundance on both the Eyre Peninsula and the Investigator Group.

Another enigmatic distribution is that of *Albizzia lophantha*, the only species restricted to Dorothee I. Symon (1971) suggested that its absence from Pearson I. may have resulted from wallaby grazing. However, no individuals were found on the ungrazed sections of Greenly I., despite appropriate habitat.

There are few exotics: only *Galium murale*, *Minuartia* sp., *Sonchus asper* and *Stellaria media* have been recorded to date, in a total flora of 92 species.

For present purposes, the significant feature of the island floras is the number of species in common (Table 2). This combined with the geophysical similarity of the islands facilitates joint classification and mapping of the island vegetations. Little else is to be gleaned from the floristic data alone.

#### Vegetation classification and description

##### Derivation of mapping units

Ten mapping units with some subdivision are presented (Fig. 2). Broadly, these follow the communities recognised by previous authors (Table 4) but there are differences in detail. My original intent was to maintain the Pearson I. community classifications of Osborn (1923) and Specht (1969), and extend them to the other islands. This proved not to be feasible: successional changes had obscured some of Osborn's communities, a number of Specht's units could not be separated satisfactorily on aerial photographs, Specht's units were not in all cases equivalent to those of Osborn, and communities defined by Osborn but not noted by Specht still existed. The present classification was derived to resolve the apparent interpretation problem but might be seen to compound the confusion. Accordingly, its derivation is given here in full.

Each mapping unit is an interpretation of a particular aerial photographic 'signature' or pattern. The 'signature' is usually determined by the emergent species with the greatest foliage cover. These species could be identified using the 250 m grid data. Mapping units so defined are thus factual statements of character species, for which they have been named

TABLE 3. Species restricted to N. Pearson I.

(a) Species characteristic of coastal land systems (including saltmarsh) <sup>a</sup>	<i>Beyeria lechenaultia</i> <i>Crassula sieberiana</i> <i>Daucus glochidiatus</i> <i>Melaleuca halmaturorum</i> <i>Suaeda australis</i>
(b) Species characteristic of non-coastal land systems <sup>a</sup>	<i>Calytrix tetragona</i> <i>Cassinia spectabilis</i> <i>Galium murale</i> (alien) <i>Monotoca scoparia</i> <i>Myoporum deserti</i> <i>Senecio cunninghamii</i> <i>Spyridium phyllicoides</i> <i>Stellaria media</i> <i>Westringia rigida</i>

<sup>a</sup> Definition follows Specht (1972) in which "coastal" is used in the strict sense of immediately coastal systems such as dunes and cliffs.

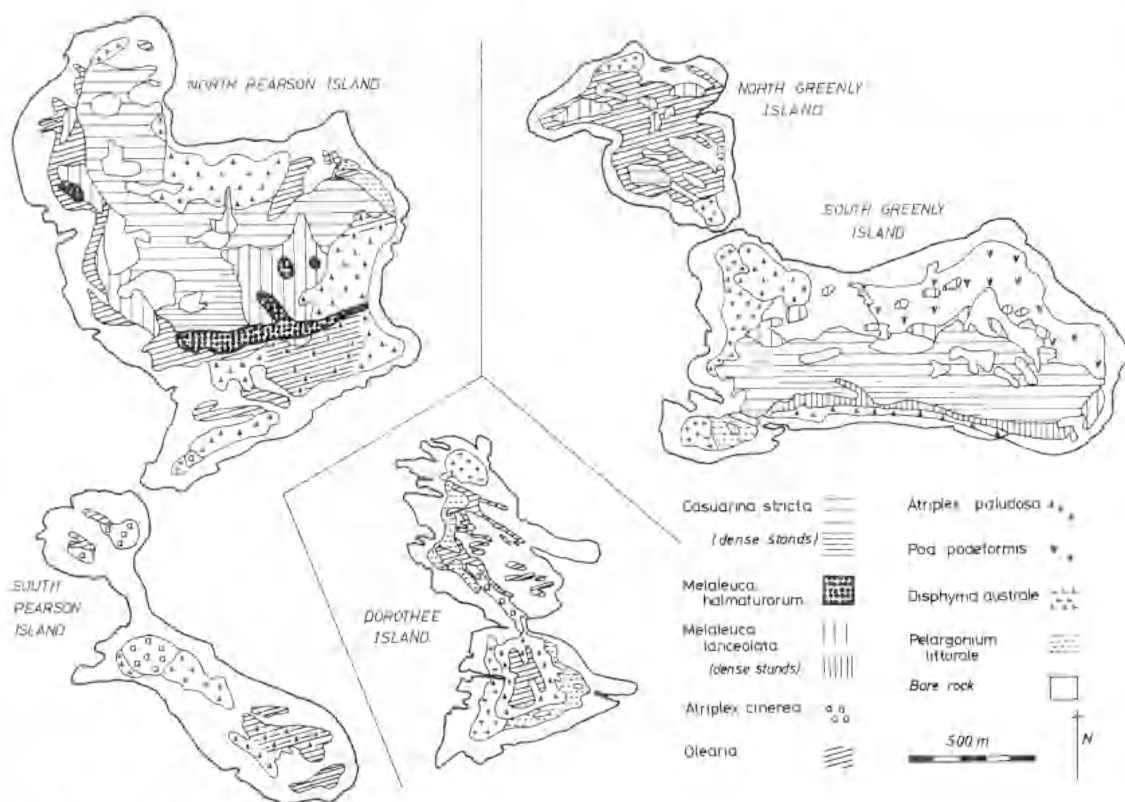


Fig. 2. Vegetation.

(Table 4). They do not define plant communities in the sense of Specht (1969) and Osborn (1923), although these may be inferred from the character species.

Actual mapping retains a degree of subjectivity. Osborn (1923) first described the mosaic nature of communities on much of Pearson I., and his comments are equally applicable to the other islands. A number of disparate communities may be within a relatively small area because of sharp disjunctions in substrate and degree of protection. In such cases, broad-scale mapping is necessarily an approximation, and boundaries between units largely a personal interpretation. The approximation still permits comparisons to be made provided its shortcomings are known. Hence the following brief descriptions of the mapping units indicate the degree of variation in species composition and abundance encompassed by individual units.

#### Description of mapping units

*Casuarina stricta* (forest or woodland is equivalent to the *Casuarina* communities of granitic

soils described by previous authors. The unit was found primarily on the two largest islands, with a small outlier on N. Greenly I. (Fig. 2). The last had been burnt four to six years previously but trees were regenerating from rootstocks. Parts of the woodland on S. Greenly I. formed a low open forest with canopies  $> 80\%$ . Equivalent areas on N. Pearson I. had been destroyed by the 1975 fires. Otherwise, *Casuarina* canopies were of the same order on both the larger islands (Table 5). *Melaleuca lanceolata* was a frequent understorey species on both islands, but otherwise understoreys contrasted. The minimal cover on S. Greenly I. was provided almost solely by *Lepidium foliosum* with occasional tufts of *Poa poaeformis*, and only six species were recorded in quadrats. The understorey on N. Pearson I. was denser and much more varied (Table 5) and no constant assemblage of species could be defined. *Scleranthus pungens*, *Olearia*, *Enchylaena tomentosa*, *Rhagodia crassifolia*, *Monotoca scoparia*, *Poa* sp., *Senecio cunninghamii* and *Calytrix tetragona* were all locally abundant (canopy extent  $>$

TABLE 4. Relationship of mapping units to previous classifications.

Unit	Structural formation (Specht 1972)	Specht (1969)	Equivalents Osborn (1923)
<i>Casuarina stricta</i>	1. Low open forest 2. Low woodland	<i>C. stricta</i> low open forest <i>C. stricta</i> low woodland	<i>C. stricta</i> woodland <i>C. stricta</i> woodland
<i>Melaleuca halmaturorum</i>	Closed scrub	<i>M. halmaturorum</i> closed scrub	<i>M. halmaturorum</i> scrub
<i>Melaleuca lanceolata</i>	1. Closed scrub 2. Open scrub	None <i>M. lanceolata</i> open scrub	None <i>M. lanceolata</i> scrub
<i>Atriplex cinerea</i>	Closed heath	<i>A. cinerea</i> low open scrub and <i>Nitritria schoberi</i> open heath	Mat plant community
<i>Olearia</i>	Open heath	<i>O. ramulosa</i> - <i>Leucopogon parviflorus</i> open heath, <i>Rhagodia crassifolia</i> - <i>Zygophyllum</i> low shrubland in part, <i>N. schoberi</i> low shrubland	<i>O. ramulosa</i> - <i>L. parviflorus</i> thicket, <i>Atriplex paludosa</i> dwarf shrubland in part
<i>Atriplex paludosa</i>	Low shrubland	<i>A. paludosa</i> low shrubland, <i>A. paludosa</i> - <i>R. crassifolia</i> low shrubland, <i>R. crassifolia</i> - <i>Zygophyllum</i> low shrubland in part	<i>A. paludosa</i> dwarf shrubland
<i>Disphyma australe</i>	Low shrubland	<i>D. australe</i> - <i>Enchylaena tomentosa</i> low open shrub	Granite cliff community, mat plant community in part
<i>Pelargonium littorale</i>	Low open shrubland	None	<i>Pelargonium</i> - <i>Carpobrotus</i> - <i>Poa</i>
<i>Poa poaeformis</i>	Tussock grassland	None	None
Bare rock	—	Bare rock	Bare rock

10%) but patchily distributed, so that almost each quadrat returned a different main understorey species. Within burnt stands of *Casuarina*, *Carpobrotus rossii* and *Olearia* were the main perennials found, with annuals *Apium prostratum*, *Calandrinia calyprata* and *Parletaria debilis*. Under the fire-opened canopies of *Casuarina* on N. Greenly I., the two perennials were also major species, with *Stipa elegantissima* and *Pelargonium littorale*. *Casuarina* woodland on N. Greenly I. had more in common, in terms of cover and species richness, with that on N. Pearson I. than with the immediately neighbouring S. Greenly I. woodland (Table 5).

*Melaleuca halmaturorum* closed scrub was limited to N. Pearson I., largely about Main Ck but with some small outliers. The unit has been adequately described by Osborn (1923). Where burnt, *M. halmaturorum* was killed outright. A sparse colonising cover of *Carpobrotus rossii*, *Apium prostratum* and *Calandrinia calyprata* was noted in burnt areas, as under burnt *Casuarina* woodland.

*Melaleuca lanceolata* open and closed scrubs were found on N. Pearson I. and N. and S.

Greenly I. Relatively open on the first two islands, thickets provided dense cover on S. Greenly I. (Table 5). In places, thickets were impenetrable and almost monospecific. *Rhagodia crassifolia*, *Threlkeldia diffusa*, *Tetragonia implexicoma* and *Enchylaena tomentosa* were associated, usually growing as climbers through the *M. lanceolata* canopies. The more open communities of N. Pearson I. have been described adequately by previous authors, whose comments apply equally to N. Greenly I. The main colonisers of burnt areas within this unit were again the species given above. Regeneration of *M. lanceolata* after burning was both from seed and rootstock.

*Atriplex cinerea* closed heath occurred on limestone terraces of N. and S. Pearson I., in blown sand on the latter, and on the calcareous loam of Dorothee I. (Fig. 2). Osborn (1923) described this unit as a 'mat plant community'. Specht (1969) distinguished three communities within Osborn's broad grouping. The three were observed in 1976 at the sites Specht indicated, but two had been much reduced by extension of *A. cinerea* over the intervening 16 years and could not be mapped ade-





quately at the scales used here. *A. cinerea* typically had a high density and a thick and luxurious cover (Table 5). Individual bushes were procumbent, usually less than 20 cm high. The population appears to be of an ecotype distinct from that of the mainland, the latter being relatively tall and erect. The procumbent habit on limestone terraces might conceivably result from a combination of water stress and damage by basking sea-lions, but those found in sand and subject to less pressure maintain the procumbent habit. Associated species within the unit have been listed by Osborn (1923). *A. cinerea* heaths on Dorothee I. were much thicker than elsewhere, with other species contributing less to the total cover. The one quadrat laid within the unit on this island was monospecific. All stands had escaped recent burning.

*Olearia open heath* was found on granitic soils on all islands but S. Greenly I., from which not only the unit but also the character species was entirely absent. The character species did not necessarily predominate within the the vegetation, but rather was the one consistently occurring member of a group of associated species, the relative abundance of which varied from site to site. *Rhagodia crassifolia* and *Correa reflexa* were the most commonly associated species on N. Pearson I., N. Greenly I. and Dorothee I. On the last, *C. reflexa* generally contributed more to the total cover than did *Olearia*, but in two small, rocky areas *Albizzia lophantha* dominated (canopy extent > 70%). *Brachyscome ciliaris*, *Frankenia pauciflora*, *Carpobrotus rossii* and *Pelargonium littorale* were frequent and abundant within the unit on the three islands also, but otherwise local assemblages varied with each island's flora. For example, *Westringia rigida* and *Spyridium phyllicoides* were locally significant in heaths on N. Pearson I., but were not found elsewhere. Despite such variation, the total cover of the unit was comparable on all three islands, as was species richness (Table 5).

In contrast, low cover and low diversity were characteristic of *Olearia* heath on S. Pearson I. The low cover might have resulted from the greater relative proportion of bare rock on this island, but this should not have greatly changed the species richness. Only *Olearia*, *Rhagodia baccata* and *R. crassifolia* were found in quadrats. The latter two species were heavily grazed by wallabies.

Osborn (1923) used *Leucopogon parviflorus* as a character plant of his equivalent com-

munity. This species was observed infrequently, on N. Pearson I. only, and was not encountered in quadrats. The vegetatively similar *Monotoca scoparia* was also infrequent. Possible misidentification aside, these observations indicate a major decline in the importance of the species since Osborn's visit (see Symon 1971).

Vegetation within burnt *Olearia* heath comprised *Olearia* and *Carpobrotus rossii* (as for other mapping units) with some *Lepidium foliosum*.

*Atriplex paludosa* low shrubland was found on granitic soils on all islands, but its occurrence on N. Greenly I. was too limited for mapping. Shrubland also covered much of the limestone terraces on N. Pearson I.—a point noted by Specht (1969) but not evident from Osborn's observations. Canopies were variable, with N. Pearson I. having the densest stands (Table 5). The most frequently occurring associated species were *Threlkedia diffusa*, *Enehylaena tomentosa* and *Rhagodia crassifolia*; with *Maireana oppositifolia* on S. Greenly I. only.

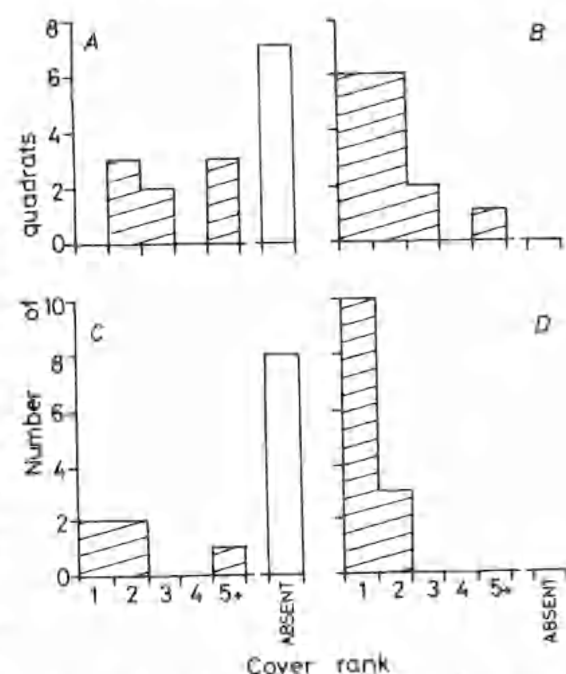


Fig. 3. Relative importance of *Rhagodia crassifolia* (A) and *Olearia* (B) in 15 quadrats mapped as *Olearia* heath; and of *R. crassifolia* (C) and *Atriplex paludosa* (D) in 13 quadrats mapped as *A. paludosa* shrubland. Burnt sites are not included. Cover rank is relative to other species in the quadrat, where rank = 1 indicates greatest cover.

Boundaries between *A. paludosa* shrubland and *Olearia* heath were diffuse. They were frequently obscured by a belt of *R. crassifolia*, a major component of both mapping units and treated by Specht (1969) as a distinct unit. Interpretation problems may have led in some cases to incorrect quadrat classification (Fig. 3). Problems of definition appear to be linked to successional processes discussed below.

The 1975 fires on N. Pearson I. had completely destroyed parts of the shrubland, killing not only the individual *Atriplex* but apparently seed stocks as well. No live *Atriplex* seedlings were present in fire zones in 1976. Little else was present for that matter—occasional young *Olearia* bushes and the annuals *Apium prostratum* and *Calandrinia calyptata*.

*Disphyma australe* low shrubland was found on substantially bare ground in the immediate coast. The community is well described by previous authors. Few species were present with *Disphyma* on N. and S. Pearson I. and S. Greenly I. relative to Dorothee I. (Table 5). No quadrats were laid in *Disphyma* shrubland on N. Greenly I., but the impression was of a more diverse flora similar to that of Dorothee I.

*Pelargonium littorale* low open shrubland occurred on N. Pearson I., Dorothee I. and S. Greenly I. on substantially bare rock distant from the sea. Plant cover was generally sparse, with most provided by *Pelargonium* and *Carpobrotus rossii*. Species richness was much higher on Dorothee I. than elsewhere (Table 5).

*Poa poaeformis* tussock grassland as a discernible unit was found only on S. Greenly I. It was characterised by a very low species richness: apart from *P. poaeformis*, the only commonly encountered species were *Nicotiana suaveolens*, *Muehlenbeckia adpressa* and *Lepidium foliosum*. Previously burnt areas within grassland could be recognised only with the aid of maps drawn up immediately after the 1974 fires.

Bare rock was present within all mapping units, and major outcropping of bare granite was common on all islands. Bare rock has been mapped as such for major outcroppings and the coastal fringe only. Some vegetation may be present in crevices of areas shown as bare.

#### Summary comparisons

The foregoing descriptions and Fig. 2 together show the broad similarities between

islands but also expose significant variation in detail, viz: the restriction of woodland and scrub units to the larger land masses; the tendency to greater species diversity in heaths and shrublands on ungrazed islands; and the peculiarity of S. Greenly I. In particular, the last possesses grassland vegetation not recorded elsewhere, has comparatively sparse and depauperate woodland understoreys, and lacks the otherwise common *Olearia* and *Atriplex cinerea* heaths. The island's most striking feature, however, is the contrast between its vegetation and that of its immediate neighbour.

Attention is also drawn to the sameness of post-fire colonising vegetation. Whatever the original vegetation, the main colonising species remain the perennials *Olearia* and *Carpobrotus rossii* and the annuals *Apium prostratum*, *Calandrinia calyptata*, and less frequently *Lepidium foliosum*.

#### Factors determining vegetation distribution and change

##### PHYSICAL FACTORS

#### Salt load

Ordination of vegetated sites with respect to altitude and horizontal distance from the coast points to the importance of salt load as a primary determinant of the vegetation distribution. This is particularly so for those sites with a westerly component in their aspect, partially or wholly facing the general direction of prevailing swells, winds and storms (Fig. 4). *Casuarina stricta* woodlands are not found below 100 m, and at this altitude are observed only in very protected localities (for example, ravines sheltered by granite tors). The bulk of woodland occurs both above 150 m and beyond 150 m from the shore. The distribution of *Melaleuca lanceolata* scrubs overlaps that of the woodlands, with slightly lower limits. The absence of both vegetations from Dorothee I. and S. Pearson I. can be simply explained by the lack of sites sufficiently high and distant from the sea. At the other extreme, the *Disphyma australe* shrubland, with its highly salt-tolerant species (Parsons & Gill 1968) occupies most of the proximal sites. *Olearia* heath, *Atriplex paludosa* shrubland and, on S. Greenly I. only, *Poa poaeformis* grasslands are found at intermediate levels with equivalent relative distributions.

This pattern is still evident, though diffuse, for the more protected leeward aspects (Fig. 5). The mosaic distribution of the various

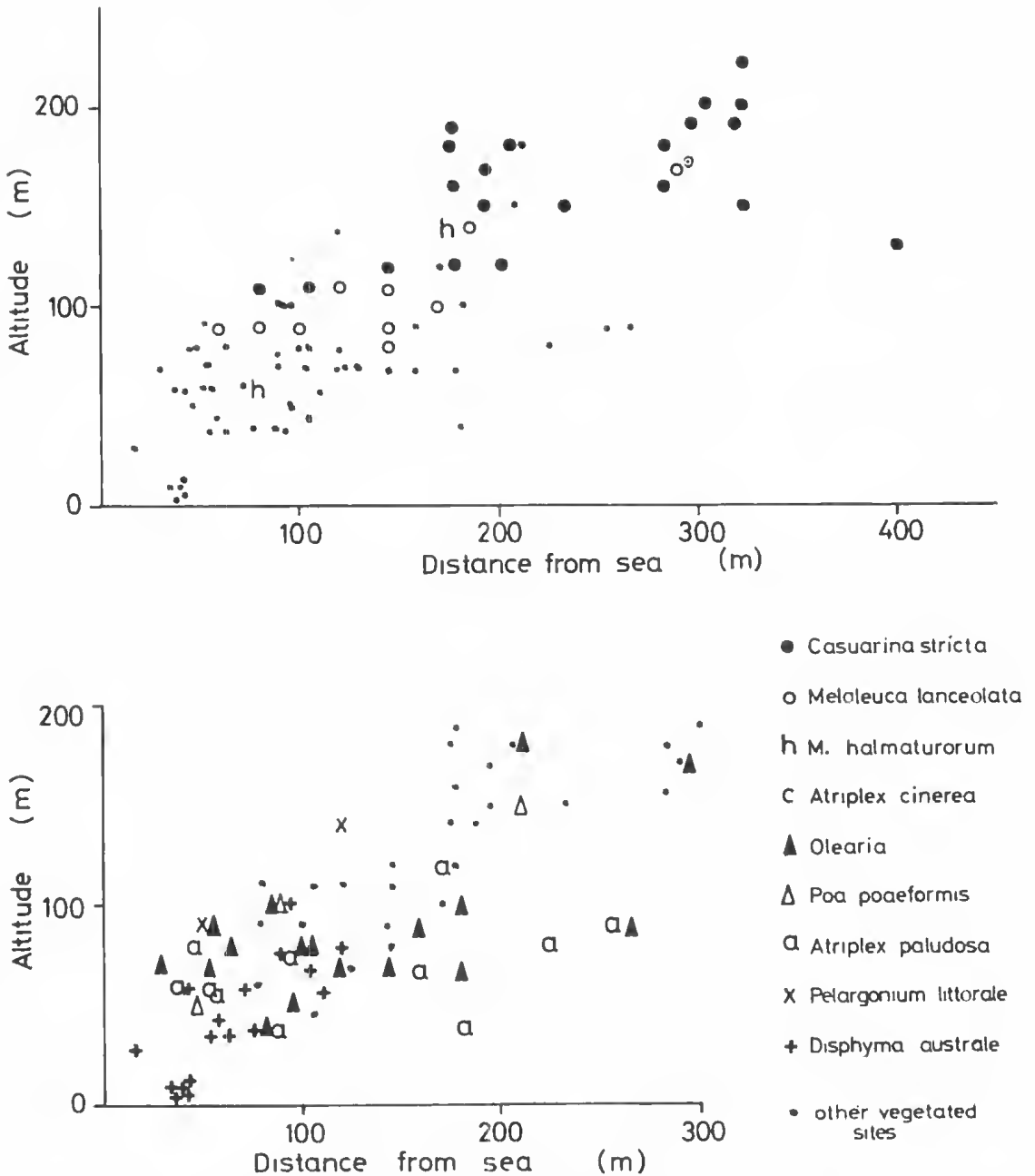


Fig. 4. Distribution of mapping units in relation to altitude and distance to nearest shoreline for sites with aspects in southwest and northwest quadrats. Two plots are provided for clarity. All vegetated sites are indicated.

mapping units in the ordination suggests a much greater influence of site-specific characteristics other than salt load, although woodland distributions indicate that salt load is still a significant, if no longer over-riding factor.

The pattern is similar to that described by Abbott & Black (1978) for islands in the

Recherche Archipelago, despite differences in character species (for example *Eucalyptus* rather than *Casuarina* forming woodlands).

The mutually exclusive possession of *Poa* grassland by S. Greenly I. and *Olearia* heaths by all other islands begs the question of replacement of heath by grassland on the former

island. Figure 6 compares the relative distribution of the two mapping units on granitic soils and the northerly aspects on which the bulk of *Poa* grassland is found. There is little difference in the relative distributions.

The distribution of *Melaleuca halmaturorum* closed scrub on N. Pearson I. appears to be an indirect result of the morphology of the island and the transport of cyclic salt. The catchment for the Main Creek system in which the scrub is located drains approximately one-third of the island. Salt deposited within the catchment would eventually make its way to the creeks by groundwater movement through the shallow, coarse soils over the largely impermeable substrate. On the other hand, the Main Creek area is well protected from the

direct effects of salt-laden winds. These two factors together permit the establishment of salt-tolerant scrubs rather than shrublands (Parsons & Gill 1968), but only on N. Pearson I. is the combination sufficiently pronounced for scrubs to develop.

*Substrates*

Substrates play only a minor part in determining the distribution of mapping units, partly because of the preponderance of granite-derived soils and granite basement, and partly through the location of subsidiary soil types. Limestone terraces would normally restrict the distribution of woodlands, the soils having poor water holding characteristics and the hardpan layer limiting the wetting profile. However, terraces occur in areas too exposed

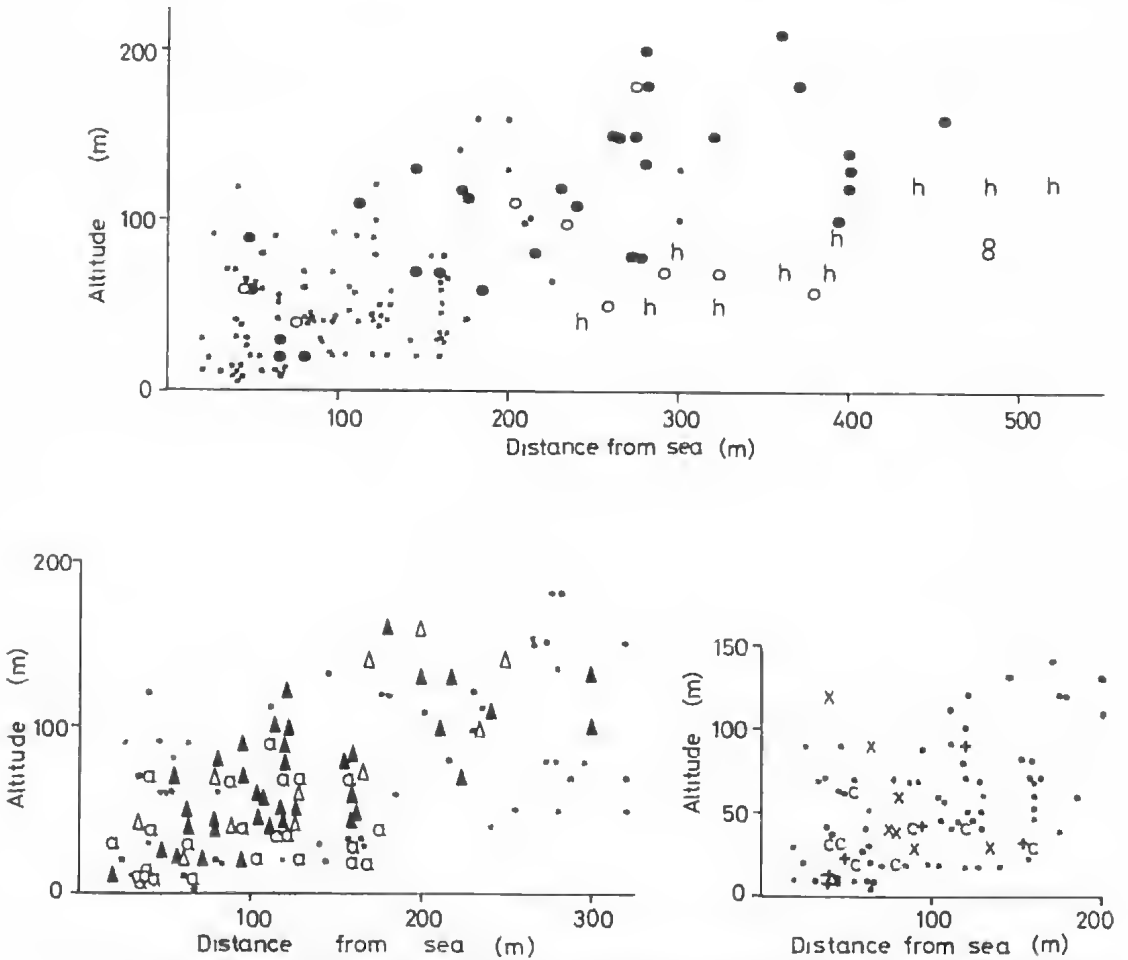


Fig. 5. Distribution of mapping units in relation to altitude and distance to nearest shoreline for sites with aspects in southeast and northeast quadrats. Separate plots are provided for clarity, with all vegetated sites indicated. See Fig. 4 for key to symbols.

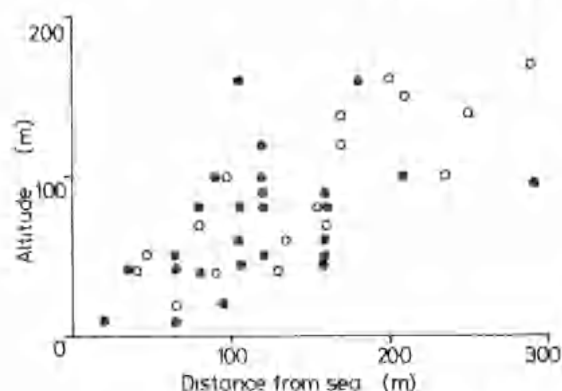


Fig. 6. Distribution of *Oleuria* heath (●) and *Poa poaeformis* grassland (○) mapping units in relation to altitude and distance to nearest shoreline at sites with aspects in northern quadrats. Only sites with either unit present are plotted.

to permit the establishment of woodland species in the first place. Exposure is also the most probable reason for the absence of a specifically associated flora.

Some negative correlations between vegetation and substrate remain. The *A. cinerea* heath is not found on granitic soils, while the *Pelargonium littorale* and *Disphyma australe* shrublands do not appear on limestone, blown sand or loam. Of more significance are the frequently encountered situations where various sites share not only the same substrate but also the same relative location and protection, yet support different vegetation.

#### Fire and succession on Pearson I.

Symon (1971) compared the field photographs of Osborn (1923) with photographs taken in 1969. He noted the following qualitative changes in distribution of major species: (a) *Atriplex cinerea* replacing *Olearia* and its associated species (Figs 1, 7 of Symon); (b) *A. cinerea* replacing Osborn's "annual plant community" of *Apium prostratum*, *Lepidium foliosum* and *Senecio luttus* (Figs 6, 7 of Symon); (c) *Atriplex paludosa* replacing *Olearia* and related species (Figs 3, 8 of Symon); (d) *A. paludosa* replacing *Rhagodia crassifolia* (Figs 2, 3, 4, 5, 8 of Symon); (e) *A. paludosa* colonising previously bare areas (Fig. 3 of Symon); (f) a "great reduction" in the number of dead and dying trees.

These processes were continuing in 1976 except in recently burnt areas; in which, from the mapping unit descriptions above, the reverse had occurred. In all vegetation burnt,

colonisers were the annuals *Apium prostratum*, *Calandrinia calyptata* and to a lesser extent *Lepidium foliosum* (i.e. the nucleus of Osborn's "annual plant community") and the perennials *Olearia* and *Carpobrotus rossii*. The islands were visited by A. C. Robinson shortly after the fires, and at that stage only the annuals were in evidence. This combined with the total destruction of *Atriplex paludosa* suggests that those areas mapped as *A. paludosa* shrubland prefire will tend to become *Olearia* heaths, while those mapped as heath will remain so—a return to the situation described by Osborn. Eventually, reinvasion of *Atriplex* from unburnt areas would diminish the importance of *Olearia* once more. The same argument could well apply to the *A. cinerea* heaths which having escaped burning were still extending into *Olearia* heath areas.

The apparent equivalence of sites supporting *A. paludosa* shrubland with those supporting *Olearia* heath is thus a reality; which of the two species is characteristic depends on fire frequency and the rate of reinvasion by *Atriplex*.

*Rhagodia crassifolia* shrublands may be postulated to be intermediate in succession from *Olearia* heath to *Atriplex* shrubland. This accounts for the occurrence of *Rhagodia* as a major associated species in both vegetations, the number of Symon's (1971) comparisons in which *Atriplex* is replacing *Rhagodia* rather than *Olearia*, the tendency noted here and by Specht (1969) for *Rhagodia* to form a vegetation unit in its own right as belts of shrubland separating the *Atriplex* shrubland and *Olearia* heath, and the consequent problem of boundary definition between the last two mapping units.

There was less evidence of such a successional interchange in the burnt portions of scrub and woodland vegetation. *Casuarina stricta* on N. Greenly I., burnt 4-6 years previously, had regenerated sufficiently to warrant recording as woodland once more. The regeneration was primarily vegetative. Similarly, burnt *Melaleuca lanceolata* individuals on N. Pearson I. were already regenerating from rootstock by November 1976, little more than a year after the fire. Both examples indicate a process of the kind described by Russell & Parsons (1978) for sclerophyllous heaths, where the pre-fire community reappears rapidly as a result of vegetative regeneration rather than successional change. On the other hand, the intensity of fire in *C. stricta* and

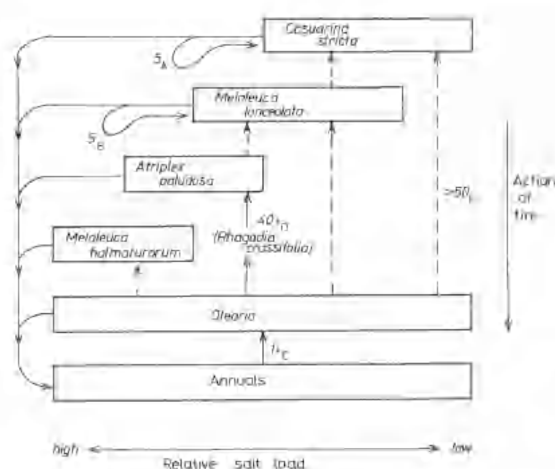


Fig. 7. Scheme outlining observed and suggested successional paths following fire, as modified by salt load, applicable to communities on granitic soils. The extent of the rectangles indicates the relative distribution of mapping units in relation to salt load, as inferred from Figs 2, 4 and 5. Observed successional paths are represented by solid lines, suggested paths by broken lines. Turnback loops are a consequence of low-intensity fires followed by vegetative regeneration rather than successional processes. Some time scales are suggested; numbers indicate years for changes. Data sources: A original, from *C. stricta* on N. Greenly I.; B original, *M. lanceolata* regrowth from rootstock on N. Pearson I.; C original, observations of A. C. Robinson and author on N. Pearson I.; D based on changes documented by Specht (1969), Symon (1971) and the 1976 survey in relation to Osborn's (1923) initial observations; E based on Osborn's (1923) description of *C. stricta* stands killed by fire at locations at which no *C. stricta* was observed in 1976. The additional impact of wallaby grazing has not been included.

*M. halmaturorum* woodland and scrub on N. Pearson I. was sufficient both to kill individuals outright and to remove seed stores. Replacement by another community must be expected: in view of the observed colonising species, *Olearia* would again become the character plant after a short interregnum of annuals. Further evidence for this is given by Osborn's record of destruction of *C. stricta* woodland "south of Main Creek", an area now containing *Olearia* heath (Fig. 2).

The previous section indicated that the potential limits to distribution of vegetation were set by physical site factors, with salt load dominating. Within this framework, the actual occurrence of units appears to be determined by fire frequency and intensity, and the rate of spread of the major species. Suc-

cessional and site relationships are summarised schematically, with a tentative time scale, in Fig. 7. Lack of information on fires between 1923 and 1969 together with the variable dispersal rates of the species concerned prevent estimation of time scales for many paths.

## BIOTIC INFLUENCES

### *Macropus eugenii* on S. Greenly I.

Relative to the other islands, S. Greenly I. displays low floristic diversity, depauperate woodlands understoreys, possession of grasslands and an absence of *Olearia* both as a mapping unit and as individuals. These characteristics cannot be explained by reference to site features and fire effects only. In particular, the absence of *Olearia* must result from a continuing exclusion process rather than an intermittent one such as fire, as a ready seed source was found on N. Greenly I. and the dispersal and establishment abilities of the species were well demonstrated on Pearson I.

Grazing by *Macropus* was the only continuing factor observed which would readily account for the differences. A comparison of species distribution between N. and S. Greenly I. shows two mutually exclusive sets of species over a variety of sites and vegetation. The restriction of a species to one or other island relates only to the presence or absence of grazing.

Few published data are available on the interaction between the wallaby and vegetation elsewhere. As with other Macropodidae, it is known to prefer herbage to browse (Andrewartha & Barker 1969). Prior to the species' introduction, the "pasture" vegetation should have been similar in composition to those of the other islands, primarily shrub with very little herb or forb.

Two mechanisms can be suggested for the vegetation changes. First, grazing pressures may have led to a reduction in preferred species, their subsequent elimination, eventual destruction of the perennial shrub cover and its replacement by a grassland in a sequence akin to effects of ungulate over-grazing in semi-arid shrublands. Trampling may also have assisted this process (see Gillham 1955). Alternatively, fire may have initiated the reduction of shrub and heath, wallaby grazing subsequently preventing the re-establishment of shrubby species. This second mechanism would be homologous with the effects of fire and rabbits on similar islands in Bass Strait

TABLE 6: Community composition and structure under *Petrogale* grazing: *Olearia*, *Pclargonium littorale* and *Disphyma australe* units.

(a) Composition in quadrats							
Quadrats laid	Island N.		S.	Stocking pressure	Island N.		S.
	Dorothee	Pearson	Pearson		Dorothee	Pearson	Pearson
	8	9	4		8	9	4
Stocking pressure	nil	mod	high	Stocking pressure	nil	mod	high
<b>SHRUB</b>				<b>SUCCULENT</b>			
<i>Olearia</i> spp.	**	**	**	<i>Carpobrotus rossii</i>	**	**	**
<i>Albizia lophantha</i>	*	—	—	<i>Disphyma australe</i>	**	**	**
<i>Arthrocnemum halocnemoides</i>	—	*	—	<i>Threlkeldia diffusa</i>	—	+	—
<i>Atriplex paludosa</i>	*	—	—	<b>HERBACEOUS</b>			
<i>Correa reflexa</i>	*	*	—	<i>Agropyron scabrum</i>	+	—	—
<i>Enchylaena tomentosa</i>	*	—	—	<i>Apium prostratum</i>	+	+	—
<i>Frankenia pauciflora</i>	—	*	—	<i>Brachyscome iberidifolia</i>	+	+	—
<i>Monotoca scoparia</i>	—	*	—	<i>Bulbinopsis semibarbata</i>	+	—	—
<i>Myoporum insulare</i>	—	*	—	<i>Calandrinia calyprata</i>	+	+	—
<i>Nitraria hillardieri</i>	+	—	—	<i>Cotula vulgaris</i>	*	—	—
<i>Pelargonium littorale</i>	**	**	—	<i>Daucus glochidiatus</i>	+	—	—
<i>Rhagodia baccata</i>	+	+	+	<i>Nicotiana suaveolens</i>	+	—	—
<i>Rhagodia crassifolia</i>	**	**	**	<i>Scleranthus pungens</i>	+	—	—
<i>Spyridium phlyticoides</i>	—	+	—	<i>Senecio cuminghamii</i>	—	+	—
				<i>Senecio lautus</i>	+	+	—
				<i>Sonchus asper</i>	+	—	—

(\*\* character species; \* locally abundant; + present)

(b) Relative cover of shrub, succulent and herbaceous species in quadrats

Quadrats laid	Island		Stocking pressure
	Dorothee	N. Pearson	
	8	9	4
	nil	mod	high
<b>No. of species</b>			
Shrub	9	10	3
Succulent	2	3	2
Herbaceous	11	5	0
<b>Total cover (%)</b>			
Median	48	66	26
Range	33-80	24-105	3-31
<b>Relative cover of shrub species (%)</b>			
Median	51	60	63
Range	30-71	11-99	25-100
<b>Relative cover of succulent species (%)</b>			
Median	22	36	40
Range	0-58	0-87	0-75
<b>Relative cover of herbaceous species (%)</b>			
Median	27	23	0
Range	11-52	0-66	0

TABLE 7: Community composition and structure under *Petrogale* grazing: *Atriplex paludosa* and *A. cinerea* units.

(a) Composition in quadrats							
	Island N.			S. Pearson	Island N.		
	Dorothee	Pearson	Pearson		Dorothee	Pearson	Pearson
Quadrats laid	3	6	7		3	6	7
Stocking pressure	nil	mod	high	Stocking pressure	nil	mod	high
SHRUB				SUCCULENT			
<i>Atriplex cinerea</i>	**	—	**	<i>Carpobrotus rossii</i>	—	+	+
<i>Atriplex paludosa</i>	**	**	**	<i>Disphyma australe</i>	+	+	*
<i>Enchylaenu tomentosa</i>	*	+	+	<i>Tetragonia amplexicomma</i>	*	—	—
<i>Rhagodia crassifolia</i>	+	*	*	<i>Threlkeldia diffusa</i>	+	+	+
<i>Frankenia pauciflora</i>	—	+	+	HERBACEOUS			
<i>Nitraria billardieri</i>	*	—	+	<i>Apium prostratum</i>	—	—	+
<i>Olearia</i> spp.	—	+	+	<i>Calandrinia calyprata</i>	—	—	+
<i>Pimelea serpyllifolia</i>	—	+	—	<i>Calocephalus brownii</i>	—	+	—
<i>Westringia rigida</i>	—	+	—	<i>Agrostis avenacea</i>	—	+	—

(\*\* character species; \* locally abundant; + present)

## (b) Relative cover of shrub, succulent and herbaceous species in quadrats

	Island		
	Dorothee	N. Pearson	S. Pearson
Quadrats laid	3	6	7
Stocking pressure	nil	mod	high
No. of species			
Shrub	5	7	7
Succulent	3	3	3
Herbaceous	0	2	2
Total cover (%)			
Median	88	71	68
Range	88-96	54-79	45-86
Relative cover of shrub species (%)			
Median	96	71	92
Range	90-100	43-100	42-100
Relative cover of succulent species (%)			
Median	4	0	7
Range	0-10	0-20	0-58
Relative cover of herbaceous species (%)			
Median	0	0	0
Range	0	0-17	0-1

described by Bechervaise (1947), Guiler (1967), Norman (1967) and Hope & Thomson (1971).

The second mechanism seems more probable, as the disappearance of *Olearia* from S. Greenly I. is recent. Although Mitchell & Behrnt (1949) referred to the elimination of "many of the smaller plants which are abundant on the subsidiary islands", Cleland (1950) reported that *Olearia* was still 'plenti-

ful on all levels on all the islands" almost fifty years after the introduction of the wallaby. This suggests that grazing of itself had been insufficient to eliminate the *Olearia*. The second mechanism also allows for the continued presence of *Atriplex* shrub populations which otherwise might also have been expected to disappear under a grazing pressure sufficient to eliminate *Olearia*. The level of grazing pressure required to prevent recolonisation by *Olearia*



is not known: Mitchell & Behradi (1949) estimated the population then to be "approaching three figures" while Robinson (1980) estimated "about 50 individuals" present in 1976.

#### *Petrogale lateralis* on S. Pearson I.

The Pearson I. wallaby colony expanded from 6 individuals in 1960 to 100-150 by 1969 (Thomas & Delroy 1971) with "at least 150" present in 1976 (Robinson 1980). The parent population on N. Pearson I. had remained relatively constant over the same period at 250-300 individuals. The figures indicate a much higher grazing pressure on S. Pearson I. than on N. Pearson I. in terms of vegetated land areas of the two islands. Changes similar to those indicated for *Macropus* grazing on S. Greenly I. might be expected, but gross changes do not appear to be taking place.

Dorothee I. provides an ungrazed vegetation for comparison with that of S. Pearson I. Herbaceous species contributed little to any of the vegetation units on S. Pearson I., but on Dorothee I. were significant components in *Olearia* heath. *Pelargonium littorale* and *Disphyma australe* shrublands (Table 6). N. Pearson I., with a lower grazing pressure than its immediate neighbour, yielded intermediate data. Further, the diversity of the shrub component was much the same in units on N. Pearson I. and Dorothee I., but was comparatively low on S. Pearson I. On the other hand, *Atriplex* communities showed little difference between islands (Table 7). Herbaceous species were relatively unimportant and there was little if any difference in diversity. Overall shrub cover in *Atriplex* shrubland and heath did not vary significantly between islands, but cover in *Olearia* heath and other shrubland units was considerably lower on S. Pearson I. than elsewhere.

The impact of *Petrogale* on S. Pearson I. has produced a mixed response in the vegetation. The low floristic diversity of the island might be attributed in part to the removal of herbaceous species by the wallaby, particularly in the vegetation mapping units of Table 6; but it may also have stemmed from the large proportion of the island (about 80% of the vegetated area) under *Atriplex* shrubland or heath. *Atriplex* communities elsewhere showed low diversity even in the absence of grazing. Further, perennial cover in these *Atriplex* communities does not seem to have altered significantly, and so erosional processes are unlikely to have increased and the long-term

primary production levels should be maintained over most of the island. A future major change from one plant community to another seems unlikely.

#### *Interaction between sea-lions and Atriplex cinerea*

Specht (1969), in seeking reasons for the increase in *Atriplex cinerea* on S. Pearson I., suggested that the sea-lion *Neophoca cinerea* may have "devastated" stands prior to Osborn's visit in 1923; but that subsequently either the *Neophoca* population had decreased or the *A. cinerea* had become "temporarily undesirable" as a basking area. He apparently based these suggestions on Osborn's lack of mention of the sea-lions. The Pearson I. colony, however, was a significant one at the time of Osborn's visit (Wood Jones 1923-1925; p. 372). Further, direct observation and dung counts in 1976 showed *A. cinerea* heaths to be the preferred basking sites.

The situation may be the reverse of that suggested by Specht. Basking grounds relative to other similarly sited locations should display differences in salt and nutrient loads resulting from the considerable urination and defecation of the sea-lions. *A. cinerea*, typically a species of the immediate shoreline, could well be advantaged as a result, particularly as its growth habit on the islands would minimise mechanical destruction.

#### *Effects of sea birds*

The often severe impact of sea-birds burrowing on vegetation is well documented (e.g. Gillham 1956, 1960, 1961, 1962; Norman 1967). The Fairy Penguin *Eudyptula minor* (Forster) in particular is noted for its effect on coastal heaths in Victoria (Gillham 1960). Large populations of this species were present on all islands but rookeries were dispersed, with rock crevices favoured for burrows (Parker & Cox 1978); a contrast with the situations examined by Gillham. Dispersed burrows combined with the preference for rocky areas reduced the impact of penguins to the point where no overt differences were noted between vegetation of rookery and non-rookery areas.

Colonies of the Short-tailed Shearwater *Puffinus tenuirostris* (Temminck) and White-faced Storm Petrel *Pelagodroma marina* (Latham) may have modified some vegetations on Dorothee I. Burrows of the former

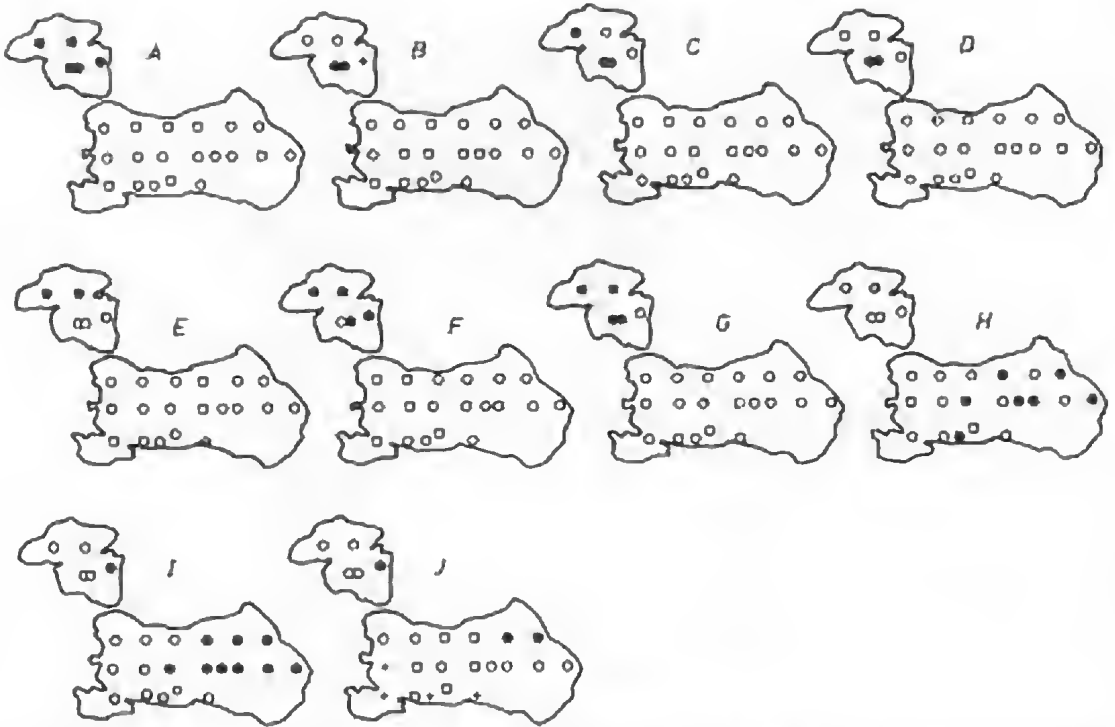


Fig. 8. Incidences of various species in quadrats on N. and S. Greenly I. (a) *Carpobrotus rossii*; (b) *Stipa elegantissima* (●) and *Brachyscome iberidifolia* (+); (c) *Danthonia* sp.; (d) *Dianella revoluta*; (e) *Correa reflexa*; (f) *Olearia axillaris*; (g) *Pelargonium littorale*; (h) *Nicotiana suaveolens*; (i) *Lepidium foliosum*; (j) *Muehlenbeckia adpressa* (●) and *Maireana oppositifolia* (+).

were found primarily within *Disphyma australe* shrubland, while those of the latter species were confined to stands of *Atriplex paludosa* shrubland. The correlation between vegetation type and bird species distribution may have resulted in part from the birds' activities, although the relative distribution of the two shrubland types can be readily accounted for by physical site characteristics.

The influence of sea-birds on vegetation may still be more pronounced than indicated above. Sampling of vegetation was not intensive, and possibly missed localised vegetation modification brought about by birds. Abbott & Black (1978) reported marked but localised vegetation change resulting from sea-bird breeding on the Recherche Archipelago. They emphasised, however, that their findings differed from those reported elsewhere because of the localised nature of the impacts.

#### Discussion

The direction of vegetation change on the islands appears to be determined by the relative importance of two sets of factors, fire

with its consequent regeneration and colonisation processes, and the impact of the larger vertebrates. The available flora and physical factors such as salt load and substrate limit the extent to which change can proceed rather than influence the direction of change. For example, at a rocky site on the immediate coast, high levels of cyclic salt will preclude the establishment of all but the most halophytic species. Whatever changes might take place, the result will still be a halophytic community (in the present context, a *Disphyma australe* low shrubland). Factors such as macropod grazing may change some characteristics of this community, but it remains recognisable. Physical constraints require a halophytic community, while the limited flora cannot provide an alternative character species to *Disphyma* within those constraints.

At sites with less extreme physical characteristics, the vegetation at any given time will depend initially on the particular combination of intensity and date of previous fires, dispersal rates and location of seed sources for colonising species, and vertebrate grazing,

trampling and burrowing. Maintenance of or succession between the various communities may proceed without reference to site characteristics. For instance, sufficiently frequent burning on N. Pearson I. may maintain an *Olearia* heath and continued *Macropus* grazing on S. Greenly I. a *Poa* grassland. Limits only become significant where change proceeds through continued exclusion of fire in the first case or a release from grazing in the second instance to the point of establishment of scrub or woodland species.

This viewpoint and the specific findings of the study have a strong bearing on island management. The introduced vertebrates need to be considered an integral component in the functioning of island vegetation and not, as is often the case, an alien influence which can be removed with only beneficial consequences. The fire regime is of more importance than has generally been recognised, controlling as it does much of the kind and distribution of vegetation.

The above information can form the basis of manipulative management of the island

vegetation, but requires a clear purpose for its rational application. Clearly, management strategies will differ markedly between various goals such as maintenance of current condition, maximised floristic diversity, preservation of particular plant communities or even use of the islands as breeding centres for rare vertebrates. Until specific goals for the islands are set, the appropriate management option would appear to be the minimisation of human interference. This would permit continuation of the dynamic processes outlined in this report, but would also require recognition and acceptance of the changes consequent on their operation.

#### Acknowledgments

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Appendix 1: *Vascular plant species recorded by various expeditions to Pearson, Dorothee, and Greenly Islands.*

+ present; — absent; N restricted to northern sections (Pearson and Greenly Is.)

Sources: <sup>a</sup>Osborn (1923); <sup>b</sup>Specht (1969), <sup>c</sup>Symon (1971), <sup>d</sup>Cleland (1950), <sup>e</sup>original.

	Pearson Island		Dorothee Island		Greenly Island		Pearson Island		Dorothee Island		Greenly Island	
	abc	e	c	e	d	e	abc	e	c	e	d	e
<b>POLYPODIACEAE</b>												
<i>Cheilanthes tenuifolia</i> (Burm.f.) Swartz	+	N	—	—	+	+						
<b>SCHEUCHZERIAACEAE</b>												
<i>Triglochin muelleri</i> Buch.	+	—	—	—	+							
<b>POACEAE</b>												
<i>Agropyron scabrum</i> (Labill.) Beauv.	+	N	+	+	—	—						
<i>Agrostis avenacea</i> Gmelin	+	N	+	—	+	—						
<i>Distichlis distichophylla</i> (Labill.) Fusset	—	—	+	—	+	N						
<i>Notodanthonia racemosa</i> (R.Br.) Zotov.	+	N	—	—	—	N						
<i>Poa poaeiformis</i> (Labill.) Druce	+	N	—	—	+	+						
<i>Vulpia bromoides</i> (L.) S. F. Grey	+	—	—	—	—	—						
<i>Stipa elegantissima</i> Labill.	—	—	—	—	+	N						
<b>CYPERACEAE</b>												
<i>Scirpus congruus</i> (Nees) S. T. Blake	+	—	—	—	—	—						
<i>S. nodosus</i> Rottb.	—	—	—	—	+	+						
<b>LILIACEAE</b>												
<i>Bulbinopsis semibarbata</i> (R.Br.) Borzi	+	—	+	+	+	—						
<i>Dianella revoluta</i> R.Br.	+	N	+	+	+	N						
<b>CENTROLEPIDACEAE</b>												
<i>Centrolepis murrayi</i> J. M. Black	+	—	—	—	—	—						
<i>C. strigosa</i> (R.Br.) Roem. & Schult.	+	—	—	—	—	—						
<b>CASUARINACEAE</b>												
<i>Casuarina stricta</i> Ait.	+	+	—	—	+	+						
<b>URTICACEAE</b>												
<i>Parietaria debilis</i> (DC.) Bail.	+	N	—	—	—	—						
<b>POLYGONACEAE</b>												
<i>Muehlenbeckia adpressa</i> (Labill.) Meisn.	—	—	—	—	+	+						
<b>CHENOPODIACEAE</b>												
<i>Arthrocnemum halocnemoides</i> Nees	+	+	—	—	—	+						
<i>Atriplex cinerea</i> Poir.	+	+	+	+	—	—						
<i>A. paludosa</i> R.Br.	+	+	+	+	+	+						
<i>Chenopodium desertorum</i> J. M. Black	+	—	—	—	—	—						
<i>Enchylaena tomentosa</i> R.Br.	+	+	+	+	—	+						
<i>Maireana oppositifolia</i> (F. Muell.) P. G. Wilson	—	—	—	—	—	+						
<i>Rhagodia baccata</i> (Labill.) Moq.	+	+	+	+	—	+						
<i>R. crassifolia</i> R.Br.	+	+	+	+	+	+						
<i>Salicornia quinqueflora</i> Bunge ex Ung.-Sterb.	+	—	—	—	+	—						
<i>Suaeda australis</i> (R.Br.) Moq.	+	+	—	—	—	—						
<i>Threlkeldia diffusa</i> R.Br.	+	+	+	+	—	+						
<b>AIZOACEAE</b>												
<i>Carpobrotus rossii</i> (Haw.) Schwante	+	+	+	+	—	+						
<i>Disphyma australe</i> (Ait.) N. E. Brown	+	+	+	+	—	+						

	Pearson Island		Dorothee Island		Greenly Island		Pearson Island		Dorothee Island		Greenly Island	
	abc	e	c	e	d	e	abc	e	c	e	d	e
<i>Tetragonia amplexicoma</i> (Miq.) Hook.f.	+	+	+	+	+	+						
<b>PORTULACACEAE</b>												
<i>Calandrinia calyptata</i> Hook.f.	+	+	+	+	+	-					+	+
<b>CARYOPHYLLACEAE</b>												
<i>Minuartia</i> sp.	+	-	-	-	-	-						
<i>Sagina apetala</i> Ard.	+	-	-	-	-	-						
<i>S. maritima</i> Don ex Sm. & Sow.	+	-	+	-	-	-						
<i>Scleranthus pungens</i> R.Br.	+	N	+	+	-	+						
<i>Spergularia</i> sp.	+	-	+	-	-	-						
<i>Stellaria media</i> (L.) Vill.	+	N	-	-	-	-						
<b>BRASSICACEAE</b>												
<i>Hymenolobus procumbens</i> (L.) Nuttall ex Schinz & Thell	+	-	+	-	-	-						
<i>Lepidium foliosum</i> Desv.	+	N	+	+	+	+						
<b>CRASSULACEAE</b>												
<i>Crasula sieberiana</i> (Schultes) Druce	+	N	-	-	-	-						
<b>MIMOSACEAE</b>												
<i>Albizzia lophantha</i> (Willd.) Benth.	-	-	+	+	-	-						
<b>GERANIACEAE</b>												
<i>Pelargonium littorale</i> Huegel	+	N	+	+	+	+					+	-
<b>OXALIDACEAE</b>												
<i>Oxalis corniculata</i> L.	+	-	-	-	+	-						
<b>ZYGOPHYLLACEAE</b>												
<i>Nitaria billardieri</i> DC.	+	+	+	+	-	-					+	+
<i>Zygophyllum billardieri</i> DC.	+	-	-	-	-	-					-	-
<b>RUTACEAE</b>												
<i>Correa reflexa</i> (Labill.) Vent.	+	+	+	+	+	N						
<b>EUPHORBIACEAE</b>												
<i>Beyeria lechenaultii</i> (DC.) Bail.	+	N	-	-	-	-					+	+
<b>SAPINDACEAE</b>												
<i>Dodonaea viscosa</i> Jacq.	+	N	+	+	+	+						
<b>RHAMNACEAE</b>												
<i>Spyridium phylloides</i> Reiss	+	N	-	-	-	-						
<b>MALVACEAE</b>												
<i>Lavatera plebeia</i> Sims var <i>tomentosa</i> Hook.f.	+	N	+	+	-	-						
<b>FRANKENIACEAE</b>												
<i>Frankenia pauciflora</i> DC.	+	+	+	+	+	+						
<b>THYMELIACEAE</b>												
<i>Pimelea serpyllifolia</i> R.Br.	+	N	-	-	+	N						
<b>MYRTACEAE</b>												
<i>Melaleuca lanceolata</i> Otto	+	N	-	-	+	+					+	-
<i>M. halimiflorum</i> F. Muell. ex Miq.	+	N	-	-	-	-					-	-
<i>Calytrix tetragona</i> Labill.	+	N	-	-	+	+					+	+
<b>APIACEAE</b>												
<i>Apium prostratum</i> Labill. ex Vent.	+	+	+	+	-	-					-	-
<i>Daucus glochidiatus</i> (Labill.) Fisch. Mey. et Avé-Lall.	+	N	-	-	-	-					-	-
<i>Hydrocotyle comocarpa</i> F. Muell.	+	-	+	-	-	-					-	-
<i>Trachymene pilosa</i> Sm.	+	-	-	-	-	-					-	-
<b>EPACRIDACEAE</b>												
<i>Leucopogon parviflorus</i> (Andr.) Lindl.	+	+	+	+	+	-					+	-
<i>Monotoca scoparia</i> (Sm.) R.Br.	-	N	-	-	-	-					-	-
<b>LAMIACEAE</b>												
<i>Westringia rigida</i> R.Br. var <i>dolichophylla</i> Ostenf.	+	N	-	-	-	-					-	-
<b>PRIMULACEAE</b>												
<i>Samolus repens</i> (Forst.) Pers.	+	-	-	-	-	-					+	-
<b>GENTIANACEAE</b>												
<i>Erythraea australis</i> R.Br.	+	-	-	-	+	-					+	-
<b>SOLANACEAE</b>												
<i>Lycium australe</i> F. Muell.	+	N	+	+	-	-					-	-
<i>Nicotiana suaveolens</i> Lehm.	+	N	+	+	+	+					+	+
<i>Solanum nigrum</i> L.	+	-	-	-	-	-					-	-
<b>SCROPHULARIACEAE</b>												
<i>Euphrasia collina</i> var <i>tetragona</i> (R.Br.) Barker	-	-	-	-	-	-					+	+
<b>MYOPORACEAE</b>												
<i>Myoporum insulare</i> R.Br.	+	+	-	-	+	+					+	+
<i>M. deserti</i> A. Cunn. ex Benth.	+	N	-	-	-	-					-	-
<b>PLANTAGINACEAE</b>												
<i>Plantago varia</i> R.Br. (s.l.)	+	-	+	-	-	-					-	-
<b>RUBIACEAE</b>												
<i>Galium gaudichaudii</i> DC.	+	-	-	-	-	-					-	-
<i>G. murale</i> (L.) All.	+	N	-	-	-	-					+	-
<b>ASTERACEAE</b>												
<i>Brachyscome iberidifolia</i> Benth.	+	-	-	+	+	-					+	-
<i>Coutla coronopifolia</i> L.	+	-	-	-	+	-					+	-
<i>C. vulgaris</i> Leutns	+	N	-	+	-	-					-	-
<i>Cassinia spectabilis</i> R.Br.	+	N	-	-	-	-					-	-
<i>Calocephalus brownii</i> (Cass.) F. Muell.	+	+	+	+	+	+					+	+
<i>Gnaphalium involucratum</i> Forst.f.	+	-	-	-	+	-					+	-

	Pearson Island		Dorothee Island		Greenly Island			Pearson Island		Dorothee Island		Greenly Island	
	abc	e	c	e	d	e		abc	e	c	e	d	e
<i>Helichrysum bracteatum</i> (Vent.) Andrews	—	—	—	—	+	N	<i>Senecio cunninghamii</i> DC.	+	N	—	—	—	—
<i>Ixiolaena supina</i> F. Muell.	+	—	+	—	+	+	<i>S. lautus</i> Forst.f. ex Willd.	+	+	+	+	+	+
<i>Olearia axillaris</i> (DC.) F. Muell. ex Benth.	—	—	+	+	+	+	<i>S. minimus</i> var <i>picridioides</i> (Turcz.) Belcher	+	—	—	—	—	—
<i>O. ramulosa</i> Labill.	+	+	+	?	—	—	<i>Sonchus asper</i> var <i>littoralis</i> J. M. Black	+	N	—	—	+	+
<i>Podolepis rugata</i> Labill.	—	—	—	—	+	+	<i>Stuartina muelleri</i> Sond.	+	—	—	—	—	—